Clinical Outcomes of Customized Healing Abutment
Systematic Review and Meta-Analysis

Yan Naing Swe

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CONTENTS

List of Abbreviations

GBR	Guided bone regeneration
et al.	et alii (Latin) in English and others
mm	Milimeter
Ncm	Newton centimeter
CBCT	Cone Beam Computed Tomography
vs.	versus (Latin) in English compared to
A	Autogenous bone
BG	Bone graft
CBCT	Cone bean computed tomography
CEJ	Cementum-enamel junction
H	Deproteinized bovine bone material
ISQ	Implant stability quotient
N/C	No comments
CHA	Customized Healing Abutment
SHA	Standard Healing Abutment
NK	Nadine Krockow
MK	Mischa Krebs
YNS	Yan Naing Swe
IIP	Immediate Implant Placement
CTG	Connective Tissue Graft
PES	Pink Esthetic Score
MBL	Marginal Bone Loss

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Declaration by candidate

I hereby declare under oath that all information in this master's thesis has been obtained and presented in accordance with academic rules and ethical conduct. This master's thesis is the product of my own independent work.

I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

This thesis has neither been submitted to another committee, nor has it been published before.

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Date, Signature

Abstract

Introduction

Oral implantology is a field that constantly seeks to improve the function, durability, and aesthetics of dental implants. One method to enhance these aspects is the use of customized healing abutments (CHA), designed to fit the shape and size of the implant site. CHA can help shape the hard and soft tissues around the implant, creating a favourable emergence profile and gingival tissue architecture. This study compared the outcomes and tissue responses of using CHA versus standard healing abutments (SHA) as socket sealing options in implant placement.

Material and Methods

The keywords "dent*" AND "impl*" AND "healing abutm*" were used to search PubMed and Cochrane databases. Articles were screened based on inclusion/exclusion criteria, and relevant data were extracted into tables. The risk of bias in the included articles was assessed using the Review Manager 5.4.1 tool. The Cochran Q test and Higgins R statistic test were used to measure statistical heterogeneity. A random effects model meta-analysis was performed with a significance level of 0.05.

Results

This study involved four randomized trials with a total of 114 patients (49 males and 65 females) who received implants with a 100% success rate. Outcomes were measured by Pink Esthetic Score (PES), marginal bone loss, papilla height, and midfacial height. The results showed that the test group (CHA) had better PES scores, while the control group (SHA) had less marginal bone changes.

Conclusion

Customized healing abutments show promise for enhancing soft tissue stability and esthetic outcomes, generally promoting alveolar sealing and maintaining the emergence profile on immediate implants without significant loss of soft and hard tissue.

Introduction

Precise placement of implants is crucial for achieving optimal aesthetic outcomes in dental procedures. The selection of the appropriate implant diameter and abutment morphology depends on the cervical dimension of the natural tooth being replaced. These parameters play a significant role in attaining sustainable and natural soft tissue contours (1).

Healing abutments serve as temporary fixtures affixed to dental implants post-insertion, facilitating proper tissue healing and shielding the implant's main body from plaque and debris build-up. Customized healing abutments (CHA) are individually tailored to conform to the specific oral anatomy of each patient, ensuring a more accurate and snug fit compared to standard healing abutments. This personalized approach is associated with enhanced healing and greater success rates for implants (2).

Utilizing customized healing abutments enables a more precise impression of the implant site, resulting in an improved fit and functionality of the final implant restoration. Research indicates that the adoption of customized healing abutments may enhance implant stability and bone regeneration, thereby elevating overall implant survival rates (3,4).

Purpose

The purpose of this study is to evaluate and compare the soft and hard tissue healing around implants with customized healing abutments and standard healing abutments.

Aim

The aim of this study is to evaluate the peri-implant tissue response and treatment outcomes after using custom healing abutments (CHA) as a socket sealing option in comparison with standard healing abutments (SHA) in dental implant placement.

Background to Thesis and Review of the literature

Biological considerations

Timing of placement

Implant placement offers an alternative to tooth reduction for fixed prosthetics or removable restorations, significantly influenced by surgical and prosthodontic protocols. From a surgical perspective, implant placement protocols are categorized by the healing period between tooth extraction and implant placement. Hämmerle et al. classified these as follows:

Type 1 (Immediate placement): No healing of bone or soft tissues.

Type 2 (Early placement with soft tissue healing): 4-8 weeks post-extraction, soft tissues healed but not bone.

Type 3 (Early placement with partial bone healing): 12-16 weeks post-extraction, both soft tissues and significant bone healing.

Type 4 (Late placement): After 6 months, fully healed socket (5).

Immediate implant placement is complex and should be performed by experienced surgeons. Key factors for success include an intact buccal bone wall, thick gingival biotype, absence of acute infection, and sufficient bone volume for 3D implant placement with primary stability. Atraumatic tooth extraction is crucial, especially in the maxillary anterior region (6). When local factors are not ideal, early placement after 4-9 weeks of soft tissue healing (Type 2) is recommended. If primary stability is questionable, a longer healing period for partial bone healing (Type 3) is suggested. Surgeons should evaluate patient risk profiles based on clinical and radiographic analysis. Prompt implant placement post-extraction can prevent alveolar bone resorption and soft tissue collapse (7).

Studies recommend positioning the implant fixture 3 mm apical and 2 mm buccal (principle 3A-2B) to counteract marginal bone resorption (8,9). Anterior sites are more prone to ridge alterations during immediate implant procedures compared to posterior sites. Using grafting material to fill significant horizontal gaps may enhance treatment outcomes (10).

Peri-implant hard and soft tissues

Peri-implant tissues resemble the periodontal tissues around natural teeth. They consist of epithelial and connective tissue elements. The epithelial tissue forms hemidesmosomal attachments to the implant surface, while the connective tissue

fibers are oriented parallel to the implant surface. Peri-implant papilla has aesthetic significance but poses a challenge to manage. To enhance the peri-implant papillary height, practitioners should optimize the blood supply and preserve the bone adjacent to the implant and the neighboring roots. Peri-implant soft tissue may undergo blanching during procedures such as abutment insertion, which may compromise the blood supply and affect the papillary height (11,12).

Surgical considerations

The conventional approach involves placing implants using a submerged protocol, followed by a second-stage surgery after osseointegration. This increases the risk of complications from additional surgeries. To avoid stage-two surgery, a flapless, non-submerged protocol using a one-piece implant or a two-piece implant with an immediate transmucosal healing abutment can be employed. A two-piece implant with a transmucosal smooth hyperbolic neck and platform-switch design has shown reduced marginal bone loss over three years. However, this technique limits changes to the transmucosal contour after implant placement (13).

An alternative strategy is the immediate connection of a transmucosal healing abutment to shape peri-implant soft tissue, avoiding stage-two surgery. Standard healing abutments, typically used in the second surgery, create a rounded, unnatural soft tissue profile, requiring additional appointments to adjust tissue contours and prevent complications such as screw loosening. Multiple adjustments can impede the healing process (3).

To optimize the emergence profile of peri-implant tissues, clinicians often use customized healing abutments. These abutments, tailored to emulate the natural profile of a tooth, are connected immediately post-surgery and left undisturbed until osseointegration and tissue maturation. Customized healing abutments can be made from various materials, each affecting peri-implant tissues differently (14).

In recent decades, efforts to improve the clinical outcomes of dental implants have focused on preserving and reconstructing peri-implant hard and soft tissues. Key factors include implant and restoration longevity, aesthetic appeal, mechanical complication incidence, bone level preservation, and overall tissue health. Strategies to prevent bone resorption and soft tissue recession after tooth extraction and implant placement include bone and soft tissue grafts, xenogeneic collagen matrices, and

customized healing abutments. These approaches aim to maintain and restore the emergence profile, especially in aesthetically sensitive areas (4).

Healing abutments (Standard vs Customized)

An implant healing abutment plays a dual role in dental implant therapy: facilitating the healing of peri-implant tissues and shielding the implant site from plaque and debris during the initial post-surgical phase. Healing abutments can be standard or customized.

Standard healing abutments, typically cylindrical and non-hexagonal, allow for easy insertion but often create a rounded gingival profile, necessitating further gingival conditioning. In the aesthetic zone, provisional restoration using a dynamic compression technique is common for both immediate and delayed placements but is limited in posterior regions due to occlusal load challenges. Here, standard healing abutments are used until osseointegration occurs, extending the treatment duration.

Pow and McMillan introduced a technique to modify standard healing abutments by adding retentive grooves and PMMA resin to shape a natural gingival profile, eliminating the need for provisional restoration. A natural soft tissue profile usually forms within two weeks. Custom-shaped healing abutments ensure proper soft tissue contouring at implant placement and avoid occlusal contact, reducing discomfort and often eliminating the need for local anesthesia (15).

Clinical Applications of Customized healing abutments

Customized healing abutments have diverse applications in both immediate and delayed implant placement procedures, utilizing techniques such as chairside fabrication and computer-aided technology. Various studies have demonstrated their promising outcomes in peri-implant tissue health. These abutments facilitate guided healing and maturation of peri-implant tissues without interfering with the osseointegration process. Furthermore, they reduce the need for multiple surgeries, decrease post-operative discomfort and morbidity associated with open-flap techniques, and shorten overall treatment duration.

Customized healing abutments also streamline the gingival conditioning process while minimizing invasiveness. When combined with CAD/CAM technology, they serve as reference points for fabricating final prostheses, ensuring precise duplication of emergence profiles and preventing misfits during abutment insertion. Additionally, their insertion with minimal soft tissue pressure can promote long-term stability (14).

Immediate Implant Placement (IIP)

Customized healing abutments are commonly used following immediate implant placement (IIP). These abutments can be fabricated using direct or indirect methods. In the direct method, a temporary cylinder is connected to the implant fixture, and resin composite is applied intraorally to capture the socket outline. In the indirect method, conventional or digital impressions of the implant position are taken, followed by fabrication using CAD/CAM techniques. The primary objectives of customized healing abutments are to preserve the emergence profiles of existing teeth and to close the implant sites (16).

Delayed Implant Placement

In cases of delayed implant placement where there is no pre-existing tooth, customized healing abutments are crucial for creating the desired contour for the final prosthesis during implant surgery. These abutments can be fabricated before implant placement by taking impressions of the edentulous area and fabricating from a diagnostic cast or by using implant planning software and milling materials.

Advancements in dental technology have led to innovative techniques, such as utilizing the contralateral tooth contour. In this method, digital software flips the contour of the contralateral tooth to create the emergence profile of the customized healing abutment. Studies have shown favourable tissue responses with the fabrication of customized healing abutments, custom impression posts, and custom abutments for the final prosthesis, all with identical transmucosal contours (17).

Hypothesis

The use of customized healing abutments in dental implantology results in significantly better clinical outcomes compared to standard healing abutments.

Research Question

Is there a clinical benefit from using custom healing abutments over standard healing abutments on peri-implant hard and soft tissues when implant placement is performed?

Material and Methods

Objective of the Study

The objective of this study is to systematically review and conduct a meta-analysis of existing literature to evaluate the clinical outcomes associated with the use of customized healing abutments in dental implantology, specifically marginal bone loss, papilla height, pink esthetic score, and mid-facial mucosa level.

Study Question/PICO Strategy

The clinical question of this study was based on the PICO study design (Population, Intervention, Comparison, and Outcome), which is a common framework for formulating research questions.

The study question was: Does the use of custom healing abutments improve peri-implant hard and soft tissue clinical outcomes compared to the use of standard healing abutments after implant placement? (Table 1)

Table 1 PICO study design for the development of study question

COMPONENT	DESCRIPTION
POPULATION (P)	Patients with a single edentulous site in anterior or posterior areas of the maxilla or mandible with the use of CHA or SHA
INTERVENTION(I)	Implant placement with the use of CHA
COMPARISON(C)	Implant placement with the use of SHA
OUTCOME (O)	Soft and hard tissues clinical outcomes: Marginal Bone Loss (MBL), Pink Esthetic Score (PES), Papilla Height and Midfacial Mucosa Height (recession).

Eligibility Criteria

Inclusion criteria

- Clinical trials with a minimum of 10 patients
- Randomized clinical trials (RCTs) published in the English language
- RCTs assessing the effects of CHA on peri-implant tissues
- RCTs including another type of socket sealing option other than SHA in the control group
- Intervention location either in anterior or posterior areas of the maxilla or mandible
- Follow-up period of at least 3 months

Exclusion criteria

- Animal studies
- Cohort studies
- Non-randomized clinical studies
- In-vitro studies
- Case reports
- Case series

Types of Outcome Measures

Marginal Bone Loss (MBL), Papilla height, Pink Esthetic Score (PES), and Midfacial Mucosa Height

Search Strategy

The search strategy was based on the PICO framework and included controlled clinical trials that assessed the impact of custom healing abutment on the peri-implant tissues. The electronic databases PubMed and Cochrane Database were searched without any time restrictions, but only English language articles were considered eligible. The search strategy and the filters used are shown in Table 2.

The electronic search was updated until December 31, 2023.

Table 2 Search strategy

Database	**Used terms**	**Filters**
PubMed	dent* AND impl* AND healing abutm*	None
Cochrane	dent* AND impl* AND healing abutm*	Trials

Study Selection and Data Selection Process

The records were independently screened at each stage by two reviewers (YNS and MK). First, the titles and abstracts were checked to remove duplicates and irrelevant records. Then, the remaining articles on customized healing abutments (CHAs) were assessed for eligibility. Finally, the full texts of clinical studies on both custom and standard healing abutments were evaluated, including only those randomized controlled trials that met the specific criteria. Any disagreements were resolved through discussion and consultation with a senior experienced reviewer (NK).

The reviewers also independently extracted data from the included articles, recording the information in predefined tables:

General Information: Study design, publication year, follow-up period and intervals, patient numbers, test and control groups, and patient-related information (age, gender, smoking status, periodontal and gingival biotype).

Surgical and Implant-Related Information: Number of implants, timing and type of placement, location, medication, local anaesthesia, insertion torque, surgical and loading protocols, implant survival rate, clinical outcomes.

Treatment Outcomes:

Pink Esthetic Score (PES): Factors include mesial and distal papilla, facial mucosa curvature, level and root convexity/soft tissue colour and texture. Some authors use a 0-14 scale with additional factors.

Papilla Height: Measured from a reference point such as the cervical margin of adjacent teeth or muco-gingival junction.

Marginal Bone Loss (MBL): Bone changes around the implant over time.

Midfacial Mucosa Height: Changes in peri-implant mucosa position around the final restoration.

Quality and Risk of Bias Assessment in individual Studies

The study utilized the Review Manager 5.4.1 tool for randomized trials. Two independent reviewers conducted assessments to determine the risk of bias. The methodological domains evaluated by the tool included random sequence generation, allocation concealment, blinding of outcome assessment, incomplete outcome data and selective reporting as shown in the following figures ***1 and 3***

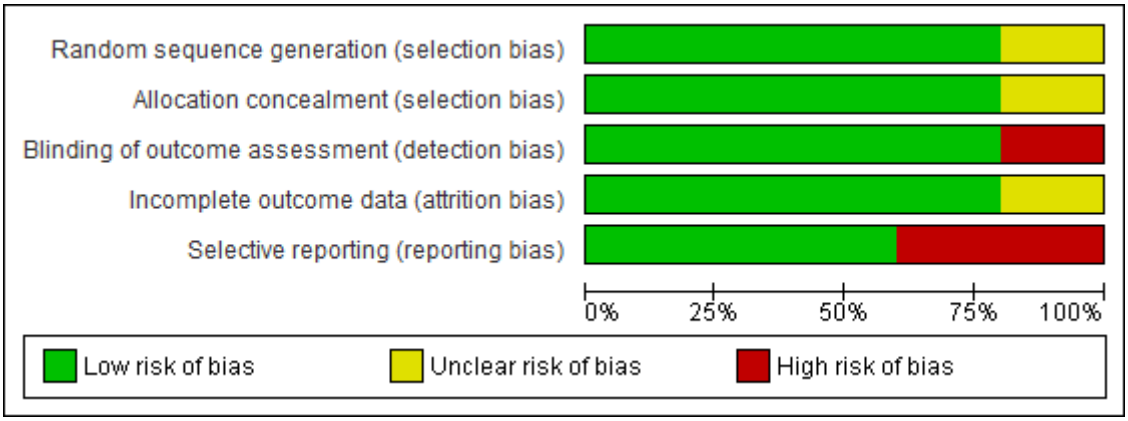

Figure 1 Risk of bias assessment (bar graph)

Data Analysis/Statistical Methods

For continuous outcomes, standardized mean differences between test and control groups were calculated. Results were analysed using meta-analysis to combine findings from similar studies, providing an overall numerical estimate. Due to variations among studies, a random-effects model was also applied, accounting for both within-study and between-study variations. Weighted mean differences and 95% confidence intervals for outcomes like MBL, PES, mid-facial level, and papilla height were calculated, with a significance level set at $p < 0.05$.

Heterogeneity was assessed using Cochran's Q test and Higgins I-squared statistic. Forest plots visually depicted differences among outcomes. Data were compiled in Excel, using standardized mean differences for identical outcomes over the follow-up period.

Results

Study Selection

The initial electronic search in the two databases resulted in the identification of 1756 records. Duplicates and triplicates removal were done before screening. Afterwards, titles and abstracts were evaluated and accordingly, 496 publications were excluded. The remaining 72 articles were evaluated.

The reasons for exclusion were as follows:

- Case reports
- Dental techniques, and
- Non-randomized clinical trials.

Finally, 5 articles were included into the analysis. The summarized selection process is presented in the following flow diagram for selection process according to PRISMA.

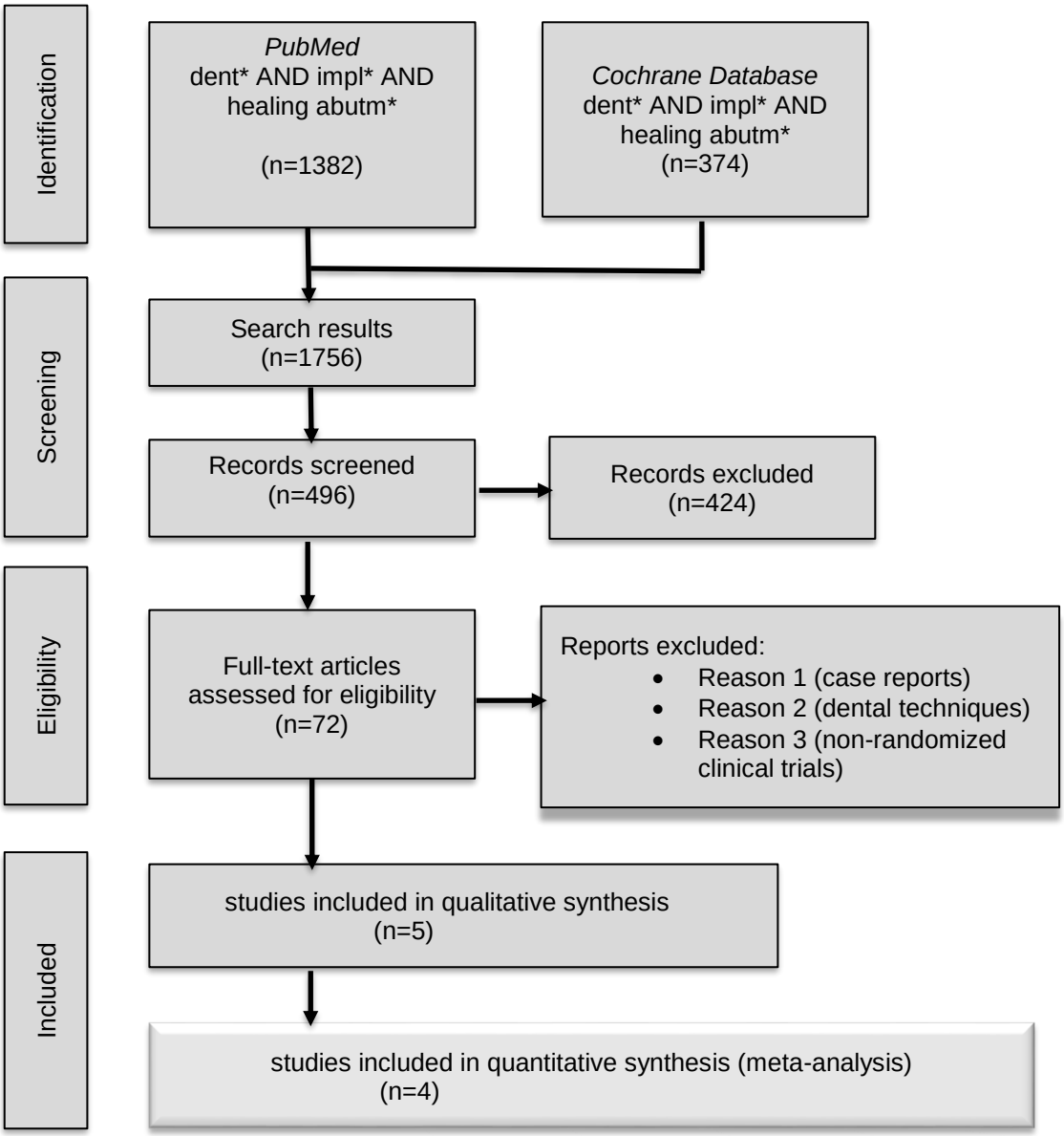

Figure 2 PRISMA flow diagram for selection process

Study Range and Characteristics

Table 3 provides an overview of the characteristics of the included studies (4,18–21). A total of 5 randomized clinical trials were analysed, involving 136 patients (60 men and 76 women), with 67 allocated to the test group and 69 to the control group.

Implant placement locations varied among the studies. Specifically, four RCTs focused on implant placement in the anterior maxillary arch, including premolars. Additionally, Beretta et al. included molar sites in both maxillary and mandibular arches. In total, 136 implants were inserted, with 123 in the maxilla and 13 in the mandible (19).

Exclusion criteria were consistent across some studies. Two trials excluded participants with uncontrolled or untreated periodontal disease, while Fernandes et al. also excluded individuals diagnosed with periodontal disease (4). However, Beretta et al. did not provide information regarding periodontal disease exclusion (19). Heavy smokers (defined as consuming more than 10 cigarettes per day) and individuals with poor oral hygiene (full mouth plaque index >25% and full mouth bleeding score >25%) were excluded from all studies.

Differences were noted in implant placement timing and surgical protocols among the studies. Fernandes et al. and Perez et al. employed immediate implantation, whereas Wan et al. and Beretta et al. utilized delayed implant placement in patients with missing teeth. Surgical procedures varied, with Beretta et al. utilizing flapless tooth extraction and immediate implant placement (IIP) with a surgical guide, while Wang et al. employed a surgical guide during the osteotomy procedure for implant placement.

Table 3 Overview of the characteristics of the included studies

Author, Year & Study Design	Number of Patients	Sex	Age	Treatment Method	Follow-up intervals
Perez et al. (2019) RCT	Total = 36 TG = 18 CG = 18	M = 19 F = 17	Range = 23-77 TG= 50.8 ± 19.5 CG = 59.0 ± 15.4	TG = CHA CG = SHA	T0: baseline; T1: after 4 months; T2: 1 year.
Beretta et al. (2019) RCT	Total = 20 TG = 10 CG = 10	M = 8 F = 12	60.75 ± 12.58	TG = CHA CG = SHA	1 month 3 months
Fernandes et al. (2021) RCT	Total = 28 TG = 14 CG = 14	M = 13 F = 15	54.00 ± 12.20 TG = 53.43 ± 12.33 CG = 54.57 ± 12.51	TG = CHA CG = Collagen matrix for socket sealing	T0: baseline; T1: 1 month, T2: 4 months, T3: 1 year.
Wang et al. (2021) RCT	Total = 20 TG = 9 CG = 11	M = 9 F = 11	30.15 ± 5.25	TG = CHA CG = Cylindrical prefabricated abutment	T1: 1 month; T2: 6 months, T3: 1 year.
Fernandes et al. (2023) RCT	Total = 32 TG = 16 CG = 16	M = 11 F = 24	48±11 TG = 51.25 ± 9.125 CG = 44.13 ± 11.477	TG = CHA CG = Connective tissue graft for socket healing	T0: baseline; T1: 1 month, T2: 4 months, T3: 1 year.

Data Extraction: qualitative Synthesis

The risk of bias assessment showed that regarding selection bias only one out of the 5 included studies (Beretta et al., 2019, Fernandes et al., 2021, Fernandes et al., 2023, Perez et al., 2019, Wang et al., 2021) one study (Wang et al., 2021) had an unclear random sequence allocation. Regarding the selection bias also the study of Wang et al., 2021 showed an unclear allocation concealment. For detection bias Wang et al. has not blinded the participants. Beretta et al., 2019 was the only study with an unclear outcome data. And two studies showed reporting bias (Beretta et al., 2019 and Wang et al., 2021) (figure 3).

Figure 3 Risk of bias assessment

Data Extraction: quantitative Synthesis

Implant survival rate was 100% for the test and control groups. The following clinical outcomes were also reported;

The Marginal Bone Loss (MB)

Marginal bone loss (MBL) analyses was conducted in the studies by Perez et al. and Wang et al. (18,20). Both studies reported no significant differences in MBL changes at mesial and distal sites separately after a 1-year follow-up period.

However, in the study by Wang et al., significant differences were observed when comparing mesial and distal MBL between two groups (customized and standard) at three different time points: implant placement, loading, and after 1 year.

Specifically, Perez et al. noted a significant difference in mesial MBL between the standard (0.6 mm) and customized (0.0 mm) groups at the 1-year follow-up. This finding underscores the importance of individualized treatment approaches in influencing MBL outcomes.

Papilla Height

Following a 1-year follow-up, there were no statistically significant differences observed in papilla height variation at mesial and distal sites. However, Fernandes et al. noted slightly less height variation in the group using customized healing abutments without xenogeneic collagen matrices compared to the group with xenogeneic collagen matrices. Specifically, at the mesial site, the customized group exhibited a papilla height variation of 0.35 mm compared to -0.54 mm in the collagen matrix group, while at the distal site, the variation was -0.38 mm for the customized group and -0.60 mm for the collagen matrix group.

Similarly, papilla height was not significantly different in the group using customized healing abutments without connective tissue graft compared to the group with connective tissue graft, as reported by Fernandes et al. At the mesial site, the customized group showed a papilla height variation of -0.07 mm compared to -0.29 mm in the connective tissue graft group, while at the distal site, the variation was -0.13 mm for the customized group and -0.38 mm for the connective tissue graft group.

In Wang and colleagues' study, after 12 months of loading, both groups exhibited a slight increase in papilla height compared to the 6-month follow-up. They found that mesial papilla height increased in the standard group from 2.59 to 2.64 at 6 months and 1-year follow-up, respectively. However, distal papilla height decreased from 2.22

(6 months) to 2.09 (1 year). These differences were statistically significant for all the time points mentioned.

Pink Esthetic Score (PES)

The customized group demonstrated notable improvement in pink esthetic score (PES) compared to the standard group at various time points: 11.44, 12.50, and 11.67 versus 9.18, 9.91, and 10.82 at implant placement, loading, and 1-year follow-up, respectively. PES exhibited statistically significant changes within both groups across these time points.

However, in the control group, PES changes at the 1-year follow-up were not statistically significant. Notably, PES scores showed improvement specifically on the distal aspect of the five assessed clinical parameters in the customized group (1.6) compared to the standard group (0.9).

Mid-facial mucosa level

No statistically significant differences were identified when assessing mid-facial mucosa variation at the 1-year follow-up. Fernandes et al. observed a more coronal position of mid-facial mucosa in the collagen matrix group compared to the customized abutment group (-0.37 ± 0.53 mm and -0.55 ± 0.64 mm, respectively), as well as in the connective tissue graft group compared to the customized abutment group (-0.6 ± 0.723 mm and -0.38 ± 0.446 mm, respectively).

In Perez et al.'s study, the mid-facial mucosal level exhibited a recession of 0.2 ± 0.4 mm for the customized group at the 12-month examination, while the standard group showed a gain of mucosal level of 0.1 ± 0.5 mm. This disparity proved to be statistically significant.

Table 4 Patient-related characteristics of studies

Author	*Local factors (Periodontal and Gingival biotype)*	*Smoking habit*
Perez et al. (2019)	Type 1 extraction socket and favourable periodontal biotype, gingival phenotype of adequate thickness (>2mm)	28 patients (77.7%) non-smokers 8 patients (32.3%) light smokers
Beretta et al. (2019)	NR	NR

Fernandas et al. (2021)	**Type 1 extraction socket** **Buccal thickness:** Test:1.11 ± 0.48 Control: 0.98 ± 0.73 **Keratinized mucosa:** Test: 4.07 ± 0.73 Control: 3.79 ± 1.53	100% non-smokers
Wang et al. (2021)	Medium thick gingival biotype Intact buccal bone plate	<10 cigarettes per day
Fernandas et al. (2023)	Type 1 extraction socket Buccal thickness: Test group: 1.15 ± 0.588 Control group: 1.25 ± 0.471 Keratinized Mucosa Test group: 3.63 ± 0.957 Control group: 4.13 ± 0.885	<10 cigarettes per day

Table 5 Implant-related information

Author	Timing of Placement	Location of Placement	Number of implants	Type of implant	Insertion Torque	Loading protocol	Implant survival rate
Perez et al. (2019)	Immediate	Anterior region of maxilla including premolars	36	Bone level tapered implants (BLT implants, Straumann, Basel, Switzerland)	TG: 37.9 ± 12.1 CG: 39.9 ± 10.8	4 months after implant placement	100%
Beretta et al. (2019)	Delayed	Gaps in maxillary or mandibular arch distal to canines	20	(iSy Implant System®, Camlog Biotechnologies, Basel, Switzerland)	NR	1 month in the maxilla 3 months in the mandible	NR
Fernandes et al. (2021)	Immediate	Maxillary anterior teeth from premolar	28	Cylindrical shape implants (Osseo Speed EV, Astra Tech	NR	Provisional crown after 4 months.	100%

		to premolar		Implant System, Dentsply Implants, Mondial, Sweden)		Definitive restoration after 6 months	
Wang et al. (2021)	Delayed	Maxillary incisors	20	3.5x11mm (Ankylos® C/X,Dentsply)	≥25 Ncm	6 months after implant placement	100%
Fernandes et al. (2023)	Immediate	Maxillary anterior teeth from premolar to premolar	32	Cylindrical shape implants (Osseo Speed EV, Astra Tech Implant System, Dentsply Implants, Mondial, Sweden)	NR	Provisional crown after 4 months. Definitive restoration after 6 months	100%

Table 5. Implant-related information

Table 6 Surgical considerations

Author	Medication	Local Anesthesia	Surgical Protocol
Perez et al. (2019)	Preoperative: 2g of amoxicillin or 600 mg of clindamycin 1 hour before surgery. Postoperative: 1g of amoxicillin 2x daily for 5 days or 300mg of clindamycin 3x daily for 5 days	4% Articaine with adrenaline 1:100,000	-Flapless extraction using fine periotomes, followed by preparation of the implant bed -A hardening alloplastic bone graft substitute was then placed in peri-implant bone defects to facilitate the subsequent application of CHA or SHA
Beretta et al. (2019)	Preoperative: 2g of amoxicillin and clavulanic acid 1h before surgery	2% mepivacaine with 1:100,000 epinephrine	-Incision, mucoperiosteal flap, osteotomy and implant placement -Application of CHA or SHA

Fernandes et al. (2021)	Postoperative: Amoxicillin 1g 2x per day for 7 days and paracetamol 1000mg 3x per day	4% Articaine with adrenaline 1:100,000	-Flapless tooth extraction, achieved by sectioning the tooth using periotomes and elevators to separate the two parts. -To facilitate optimal healing and support, gaps of at least 2 mm were filled with deproteinized bovine bone mineral (DBBM) material.
Wang et al. (2021)	NR	Primacaine (Articaine 68 mg, adrenaloine 17µg)	-Implant socket preparation using surgical guide. -Immediate individualized or conventional healing abutments were placed each in its group.
Fernandes et al. (2023)	Postoperative: Amoxicillin 1g 2x per day for 7 days and paracetamol 1000mg 3x per day	4% Articaine with adrenaline 1:100,000	-Flapless tooth extraction, achieved by sectioning the tooth using periotomes and elevators to separate the two parts. -To facilitate optimal healing and support, gaps of at least 2 mm were filled with deproteinized bovine bone mineral (DBBM) material.

Table 7. Clinical outcomes of the selected studies

Author	Clinical Outcomes
Perez et al. (2019)	• Mid-facial mucosal/changes in the width of keratinized gingiva • Peri-implant bone level or Marginal Bone Loss (MBL) • Full Mouth Bleeding Score (FMBS) • Full Mouth Plaque Score (FMPS) • Implant success rate; Comparison of implant failure and complication rate • Papilla Index (PI) or Jemt Index and Pink Esthetic Score (PES)
Beretta et al. (2019)	• Functional Implant Prosthodontics Score (FIPS) • Perceived pain after crown insertion using the Numerical Rating Scale (NRS)
Fernandes et al. (2021)	• Peri-implant tissues dimensional changes: Linear Buccal Changes, Buccal Volumetric Variation (BVv), Papilla presence and midfacial mucosa height
Wang et al. (2021)	• Pink esthetic score, papilla height, papilla proportion and radiographic marginal bone level.

	•	Visual analog scale (patient self-assessment scores)
Fernandes et al. (2023)	•	Peri-implant tissues dimensional changes: Linear Buccal Changes, Buccal Volumetric Variation (BVv), Papilla presence and midfacial mucosa height

Meta-Analysis

Wang et al., Fernandes et al. and Perez et al studies were included in meta-analysis. 95% confidence interval was used in the estimation and statistical heterogeneity was measured by the Cochran Q test and Higgins I^2 statistic test.

Marginal bone loss

The meta-analysis in Figure 4 examines the mesial marginal bone loss between four and six months (M1) from studies by Wang et al. and Perez et al. The results show moderate heterogeneity with a Cochran's Q value of 2.04 (p = 0.15) and an I^2 of 51%. The standardized mean difference (SMD) is -0.30 (95% CI: -5.39 to 4.80). Perez et al. (2019) has an SMD of -0.65 (95% CI: -1.32 to 0.02), suggesting a reduction in bone loss in the experimental group, while Wang et al. (2021) shows an SMD of 0.16 (95% CI: -1.02 to 1.34). The results indicate that there is variability in outcomes, with Perez et al. showing statistically significant results favoring the experimental group.

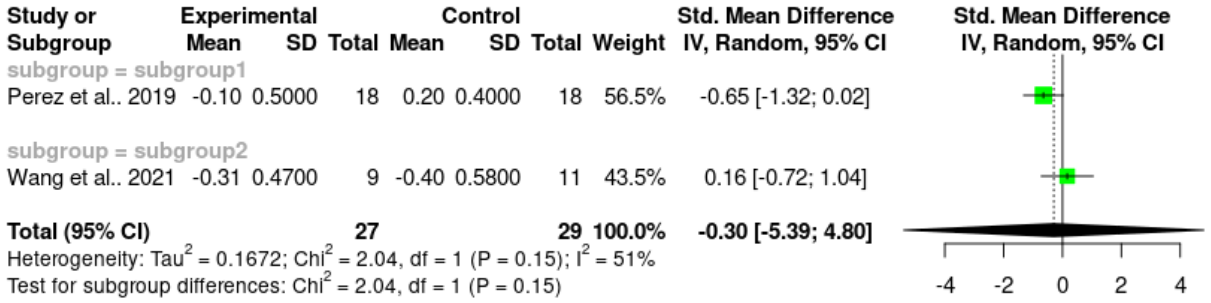

Figure 4 Meta-analysis for Mesial marginal bone loss M1

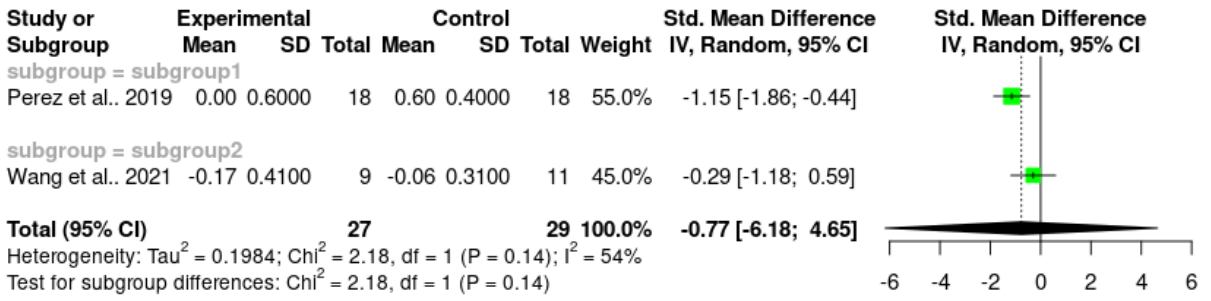

Figure 5 Meta-analysis for Mesial marginal bone loss M2

In Figure 5, the analysis continues to evaluate the mesial marginal bone loss at the one-year mark (M2). The heterogeneity remains moderate, indicated by a Cochran's Q value of 2.18 (p = 0.14) and an I^2 of 54%. The overall SMD is -0.77 (95% CI: -6.18 to 4.65), with Perez et al. (2019) showing an SMD of -1.15 (95% CI: -1.86 to -0.44), again suggesting a significant reduction in bone loss in the experimental group. Wang et al. (2021) has an SMD of -0.29 (95% CI: -1.18 to 0.59), indicating less pronounced results. The forest plot confirms that after one year of treatment, both studies lead to results favoring the test group over the control group, particularly in Perez et al.'s study, which shows consistent statistical significance.

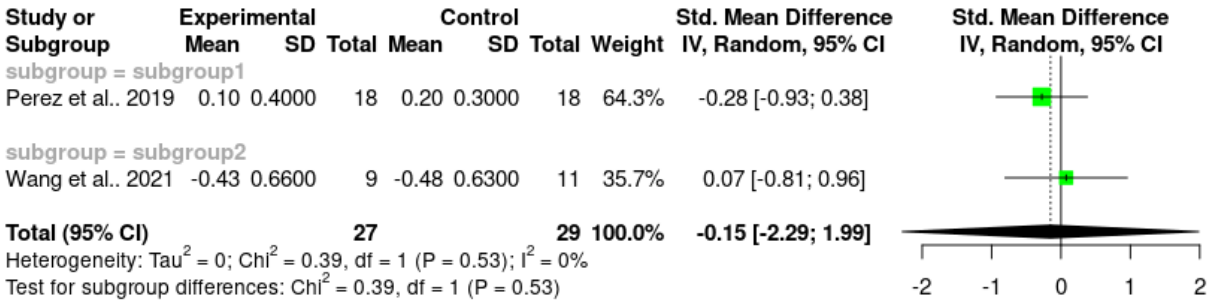

Figure 6 Meta-analysis for Distal marginal bone loss M1

The meta-analysis in Figure 6 evaluates distal marginal bone loss between four and six months (M1) from studies by Perez et al. and Wang et al. The results indicate homogeneity, with Cochran's Q value of 0.39 (p = 0.53) and an I^2 of 0%. The overall standardized mean difference (SMD) is -0.15 (95% CI: -2.29 to 1.99), suggesting no significant difference between the experimental and control groups. Perez et al. (2019) shows an SMD of -0.28 (95% CI: -0.93 to 0.38), while Wang et al. (2021) presents an SMD of 0.07 (95% CI: -0.81 to 0.96). The forest plot demonstrates that neither study shows a significant advantage for the experimental group in reducing distal marginal bone loss during this period.

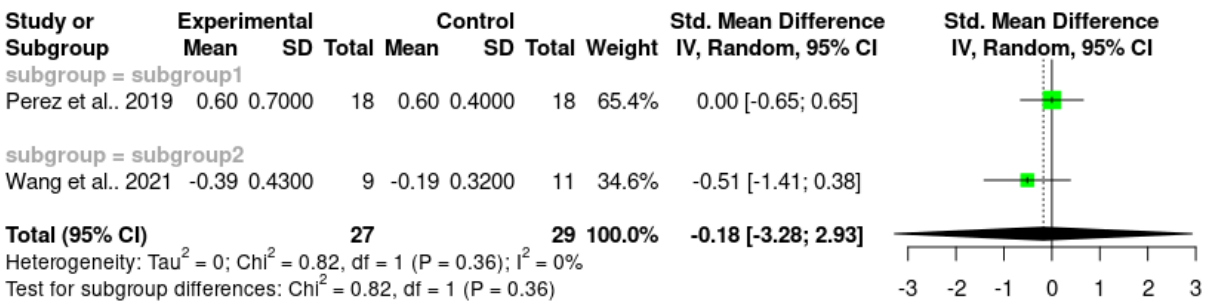

Figure 7 Meta-analysis for Distal marginal bone loss M2

In Figure 7, the analysis continues to evaluate distal marginal bone loss at the one-year mark (M2). Similar to the earlier time frame, the studies exhibit homogeneity with Cochran's Q value of 0.82 ($p = 0.36$) and an I^2 of 0%. The overall SMD is -0.18 (95% CI: -3.28 to 2.93), again indicating no significant difference between the groups. Perez et al. (2019) shows an SMD of 0.00 (95% CI: -0.65 to 0.65), while Wang et al. (2021) reports an SMD of -0.51 (95% CI: -1.41 to 0.38). The forest plot confirms that after one year, the results of Wang et al. favour the control group, while Perez et al.'s results do not show a preference for either group. This indicates that the experimental interventions do not significantly impact distal marginal bone loss.

Papilla height

The meta-analysis in Figure 8 evaluates the mesial papilla height from studies by Wang et al. and Fernandes et al. conducted between four and six months. The results show substantial heterogeneity among the studies, as indicated by Cochran's Q value of 13.70 ($p < 0.01$) and an I^2 of 85%. This high level of heterogeneity suggests considerable variability in the study outcomes. The overall standardized mean difference (SMD) is 1.32 with a 95% confidence interval (CI) of [2.73, 5.37], which indicates that Wang et al.'s study has a significantly higher mesial papilla height compared to the control, thus highlighting its statistical significance.

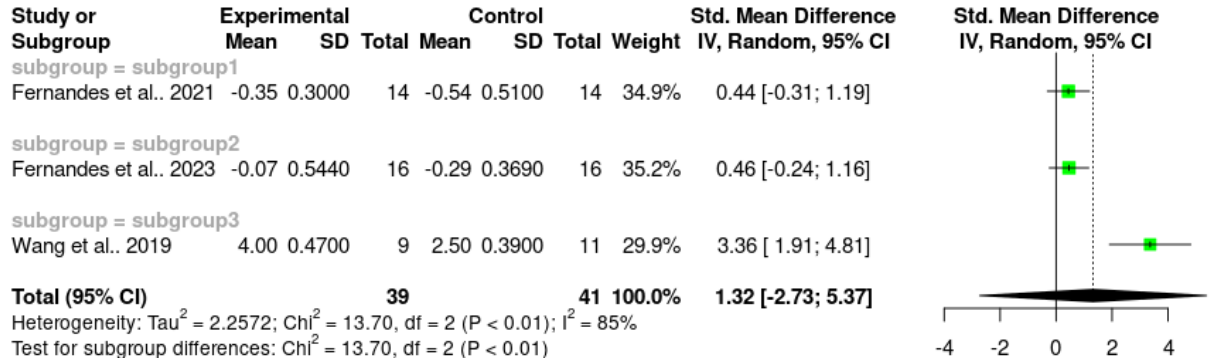

Figure 8 Meta-analysis for mesial papilla height M1

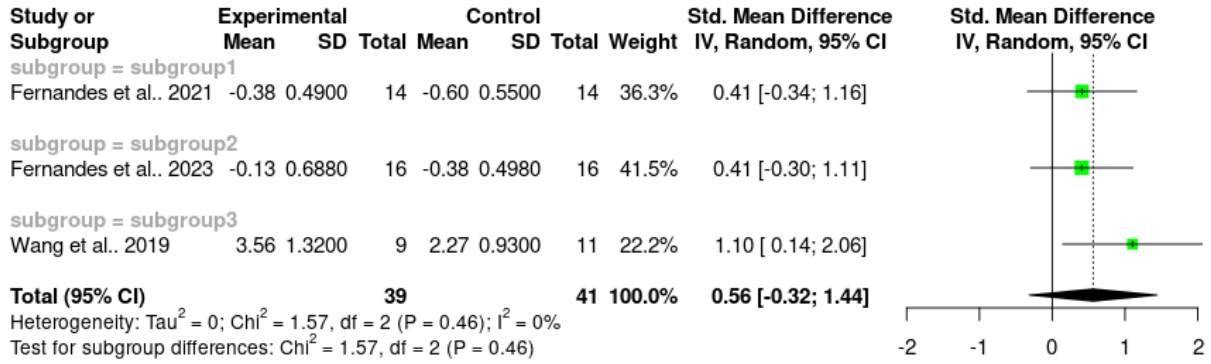

Figure 9 Meta-analysis for distal papilla height M1

In Figure 9, the analysis focuses on the distal papilla height across the same studies. Here, Cochran's Q value of 0.01 ($p = 0.99$) and an I^2 of 0% indicate no heterogeneity, demonstrating that the studies are consistent with each other regarding this variable. The combined SMD is 0.41 with a 95% CI of [0.09, 0.74], favouring the experimental group. Similar to the mesial papilla height results, the study by Wang et al. shows statistical significance, confirming that the experimental intervention consistently improves distal papilla height compared to the control across different studies.

Pink Esthetic Score (PES):

The meta-analysis presented in Figure 10 evaluates the Pink Esthetic Score (PES) from two studies by Wang et al. and Perez et al. over a one-year period. The analysis aims to assess the homogeneity of the studies. The results indicate no significant heterogeneity, as evidenced by a Cochran's Q of 0.01 (p = 0.91) and an I^2 of 0%, suggesting the studies are highly consistent with each other. The combined standardized mean difference (SMD) between the experimental and control groups is 0.54, with a 95% confidence interval (CI) of [0.14, 0.95], favoring the test group. This implies that, on average, the experimental interventions led to a significantly higher PES compared to the controls. The consistency and positive outcome across studies reinforce the reliability of the test group's efficacy in improving PES.

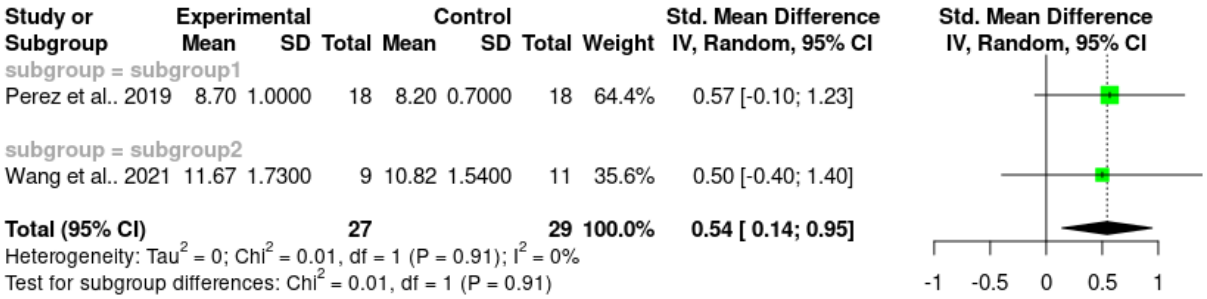

Figure 10 Meta-analysis for Pink esthetic score M2

<u>Mid-facial mucosal level</u>

The meta-analysis in Figure 11 evaluates the mid-facial mucosal level (recession) at the one-year evaluation from studies by Fernandes et al. and Perez et al. The studies show varied outcomes. Fernandes et al. (2021) includes two subgroups with standardized mean differences (SMD) of -0.30 (95% CI: -1.04 to 0.45) and 0.36 (95% CI: -0.34 to 1.06), while Perez et al. (2019) shows a positive SMD of 0.71 (95% CI: 0.04 to 1.39). The overall effect size across all studies is 0.27 (95% CI: -0.09 to 1.54), with a Cochran's Q value of 3.91 (df = 2, p = 0.14) and an I^2 of 49%, indicating moderate heterogeneity. This forest plot demonstrates that while the studies are statistically similar, the results favor the test group in Perez et al.'s study.

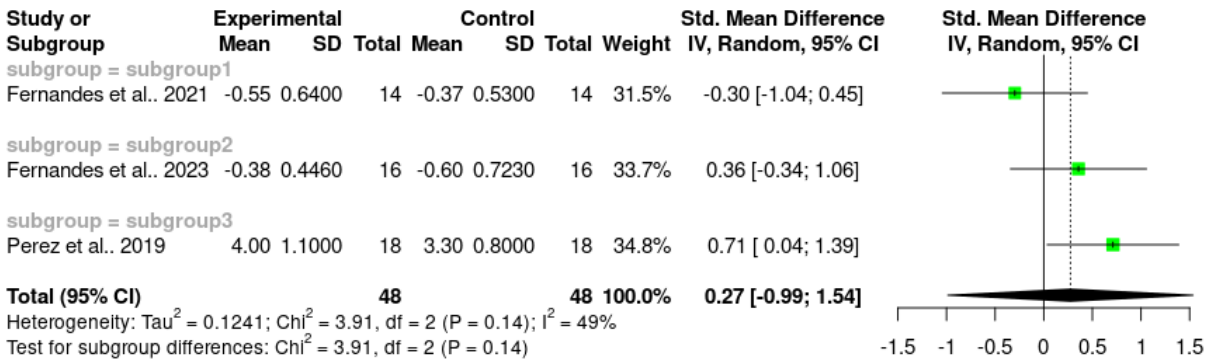

Figure 11 Meta-analysis for Mid-facial mucosal level/ recession M2

Discussion and Conclusion

Discussion

This systematic review aimed to assess how the use of customized healing abutments (CHA) after immediate or delayed implant placement affects the response of both hard and soft tissues surrounding the implants. Various techniques have been highlighted in the literature to stabilize or enhance peri-implant tissues, preserve the emergence profile, and optimize gingival architecture. For instance, the socket shield technique (SST), introduced by Hürzeler in 2010, has gained popularity for stabilizing alveolar ridge dimensions after immediate implant placement (IIP), particularly in aesthetically sensitive areas. Studies have shown that SST helps preserve marginal bone levels and alveolar bone, achieving pleasing esthetic results, although further research is needed to determine its long-term outcomes and prevent complications (22).

Connective tissue grafting (CTG) is recommended to minimize soft tissue recession, especially in the anterior maxilla where thin gums are common. CTG contributes to midfacial soft tissue stability and can augment keratinized mucosa height, facilitating proper hygiene measures and preventing soft tissue inflammation. Studies have supported the efficacy of CTG in maintaining healthy peri-implant tissues (23,24).

Immediate implant placement (IIP) and immediate provisionalization in the esthetic area are advocated for their ability to provide good esthetic results by preserving alveolar bone and gingival tissue architecture. The dynamic compression technique, involving the use of provisional restorations to shape soft tissue after healing cap removal, is proposed to achieve the desired gingival tissue emergence profile (25).

Another option for alveolar ridge preservation is the use of xenogeneic non-cross-linked extracellular resorbable collagen matrix. This biomaterial has shown safety, feasibility, and effectiveness for alveolar ridge preservation when combined with bone grafts (26). Porcine acellular dermal matrix (pADM) has also been studied and found effective in enhancing peri-implant soft tissue esthetic outcomes, offering advantages over traditional connective tissue grafts (27).

Our review found a limited number of clinical trials on this topic, with only a few recent randomized clinical trials meeting our inclusion criteria. These trials evaluated CHA and SHA in the test and control groups, respectively, with most studies focusing on the manufacturing techniques of CHA and case reports.

Regarding antibiotic administration, all patients in the studies received either amoxicillin or clindamycin, with clindamycin being used in cases of allergy to amoxicillin. However, the use of amoxicillin combined with clavulanic acid in the Beretta et al. study is not considered justified, as prophylactic antibiotic treatment with amoxicillin alone is preferred.

Careful consideration of patient selection criteria and surgical protocols is crucial for successful implant therapy outcomes. Further research, particularly long-term clinical trials, is needed to better understand the efficacy and long-term effects of these techniques on implant success and patient satisfaction. Patient selection focused on individuals with type 1 extraction sockets, favorable periodontal and gingival biotypes, and without soft tissue defects or recession. Wang et al. also included patients with intact buccal bone plates and medium-thick gingival biotypes. However, Beretta et al. did not consider these factors, possibly due to their focus on implants in posterior areas where periodontal/gingival biotypes are generally favorable.

The meta-analysis conducted in this study revealed significant insights into the clinical outcomes associated with CHA compared to SHA. The analysis demonstrated that while CHA generally improved the Pink Esthetic Score (PES), indicating better esthetic outcomes, there was notable variability in marginal bone loss (MBL) results across the included studies. Specifically, the CHA group showed a significant reduction in mesial marginal bone loss at various follow-up points, suggesting enhanced peri-implant bone stability. However, distal marginal bone loss results were less consistent, with some studies favoring SHA. Papilla height measurements also indicated a trend towards improved outcomes with CHA, although high heterogeneity was observed, highlighting the need for standardized protocols in future research. Overall, the meta-analysis underscores the potential of CHA to enhance esthetic and functional outcomes in implantology but also emphasizes the necessity for further long-term studies to validate these findings and address the observed variability.

It is important to recognize the differences in methodologies among the included analyses. Comparing data derived from these different methods may pose a limitation for this review. It is strongly recommended that future RCTs employ longer follow-up periods and standardized outcome measurement methodologies. Furthermore, the impact of the type of customization on peri-implant responses should be thoroughly investigated, given the diversity of materials and fabrication methods available.

Conclusion

In conclusion, customized healing abutments demonstrate potential benefits in oral implantology, particularly for enhancing soft tissue stability and esthetic outcomes. However, they may still result in early marginal bone changes compared to standard healing abutments. Despite these limitations, this review indicates that customized healing abutments generally promote alveolar sealing and maintain the emergence profile on immediate implants without significant loss of soft and hard tissue.

Future Outlook

Some possible areas of focus and future directions for studies on customized healing abutments include:

Long-term Outcomes:

Investigating the long-term stability and health of soft tissue and implants associated with customized healing abutments. More studies with extended follow-up periods are needed to provide definitive answers.

Standardization of Protocols:

Establishing standardized protocols for designing, fabricating, and placing customized healing abutments to improve consistency and reproducibility. This standardization will facilitate more reliable comparisons of study results.

Comparison with Traditional Approaches:

Conducting comparative studies to evaluate the advantages and disadvantages of customized healing abutments versus traditional approaches, such as standard healing abutments or other soft tissue management techniques.

Patient-Centered Outcomes:

Assessing patient satisfaction, comfort, and quality of life after implant placement with customized healing abutments. Understanding patient perspectives will guide treatment decisions and enhance overall patient experience.

Advanced Materials and Technologies:

Exploring how materials science and digital technologies can enhance the design and fabrication of customized healing abutments. Incorporating novel materials and digital workflows could improve precision, aesthetics, and tissue integration.

Customization for Specific Clinical Situations:

Investigating how customized healing abutments can be tailored to specific clinical scenarios, such as challenging anatomical features or esthetic requirements. Research in this area can lead to more personalized treatment approaches.

List of Tables

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